REPORT

—ON THE—

Assiniboine River and Artesian Wells

AS SOURCES OF SUPPLY

—AND ON—

A System of Water Works for the City of Winnipeg,

BY H. N. RUTTAN, CITY ENGINEER,

—WITH—

Analyses of Waters by Drs. Drown, Girdwood and Hutton,

—AND—

Report on the Condition of Assiniboine River by Dr. Patterson and H. N. Ruttan, C.E.

WINNIPEG, MANITOBA,
20th October, 1896.

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Winnipeg, 1st Oct., 1896.

The Chairman and Committee on Fire, Water and Light of the City Council of Winnipeg :—

GENTLEMEN,

I have the honor to submit the following report upon the water supply and also a system of water works for the City of Winnipeg.

Two sources of supply have been examined :

1. THE ASSINIBOINE RIVER.
2. ARTESIAN WELLS.

A number of analyses of these waters have been made by Dr. W. A. B. Hutton, Prof. of Chemistry, Manitoba College and Dr. G. P. Girdwood of McGill College Medical Faculty, Montreal.

An analysis and report on the interpretation of the analyses of Artesian well waters has been made by Dr. T. M. Drown of the Massachusetts Institute of Technology, Chemist of the Mass. State Board of Health.

Analysis alone is not conclusive as to the quality of the water. In addition to analysis the sources of supply, the character of the watershed, the kind of soil from which the water is obtained or through which it flows, the vegetation on the watershed, the population and manufactures by which the water may be affected, must be known, in order to make it possible to determine whether the water is suitable for use or not.

ASSINIBOINE RIVER.

A number of analyses are given in the attached table from, the report of the Massachusetts State Board of Health for 1891, of waters which are known to be uncontaminated by sewage; by comparing these with the analyses of the Assiniboine water it will be seen that they are in some of their constituents very similar, though, as stated in the report and by Dr. Hutton, these waters would, according to European practice, be classed as polluted.

The Mass. State Board of Health has gone very fully into an examination of streams with a view to determining the amount of sewage contamination caused by population on watershed.

The following is a statement of the result of the examinations :

"From an average of observation of 15 streams it is found "that it requires 21 persons per square mile to increase the "chlorine by .01 per 100.000. The foregoing results are based "on an average of a year or more. In summer when the flow is "small the population corresponding to .01 excess of chlorine is "much smaller." The average of several observations on streams being 7 persons per square mile. As .01 of chlorine above the normal is merely an indication of very slight contamination, and as the population on the watershed of the Assiniboine and Lake Manitoba does not exceed one twentieth of the minimum above given it may be stated with certainty that the Assiniboine supply is not contaminated by sewage. In Massachusetts the watersheds are comparatively steep, the streams rapid, the valleys and hillsides often rocky, so that surface contamination such as sewage is at once carried into the beds of streams. In Manitoba on the contrary the watersheds are very flat and the soils chiefly are impervious clay—much of the sewage deposited on the watershed will therefore never reach the

streams. On the other hand the evaporation on the Assiniboine watershed, owing to the open character of the country and the constant winds, is excessive, and the summer flow of the river considering the extent of the drainage area is very small, being after a series of extremely dry seasons only about .015 of a cubic foot per square mile of drainage area; the drainage area being 58,000 square miles.

If it is assumed that it requires a population of 10 per square mile to increase the chlorine by .01 per 100.000 an evenly distributed population of 1.200.000 might be placed on the Assiniboine watershed, before any serious contamination of the water could occur.

From an examination of the analyses of water known to be uncontaminated by sewage it will be seen that the free and albuminoid ammonias approximate those of the Assiniboine, and all indications are that the ammonias in the Assiniboine water are derived from the same sources as those in the waters referred to, viz, dissolved from grasses, leaves and roots, etc.

Referring to one of the above waters the report says:

" Experiments made with this water and others of the same " general character show that this dissolved nitrogenous matter " will remain constant in composition for many months without " the development of free ammonia or other indications of decay."

Though it is believed that the Assiniboine water is of this character it has not yet been determined by analysis extending over long periods.

The solid matter in the Assiniboine, 50 grains per gallon is very high (being however only 60 per cent of that of the well water) and the hardness of the water 24 degrees is also very high.

The solids and the hardness may be very materially reduced by a suitable system of softening and filtration. In order to

indicate what may be done by such a system the following analysis of water before and after filtering (from Mr. Mathew's description of the Southampton Water Works, Vol. 108, Transactions Inst. C. E.) is given.

PARTS PER 100.000.

	Well Water.		Softened Water.
Total solid matter	31.69		14.07
Organic carbon	.024		.021
Organic nitrogen	.012		.013
Ammonia	.005		.004
Nitrogen as nitrates and nitrites	.365		.381
Total combined nitrogen	.381		.397
Chlorine	1.6		1.6

The capacity of the Southampton softening works is 3,000,000 per day.

The cost of the works was about $50,000, and the cost of treatment is about ½ per cent per 1,000 gallons.

ARTESIAN WELLS.

A map is submitted herewith, shewing the location and other particulars of a number of wells in the City. *

The wells are as a rule 5 inches in diameter cased with wrought iron pipe.

The casing extends from above the surface of the ground to the bottom of the well or in cases where the well is bored into the rock, the casing stops at the rock.

Most of the wells obtain their supply from the drift formation on top of the rock or from sand and gravel beds lying between the surface clay and the limestone.

* Map may be seen in City Engineer's Office.

A sketch illustrating the probable sources of supply of the underground waters from Lake Manitoba is attached.

The rock surface underlying Winnipeg is generally from 50 to 100 feet below the surface of the ground.

The surface elevation of the water in each well is given in blue on the plan and indicates closely the slope of the water table and shows why flowing wells can be obtained in some portions of the City and not in others.

The probable cause of the sudden dip of the water table towards the rivers is that the water finds outlets in the river beds and banks. Strong springs of this water have been found in pier foundations on the Red and Assiniboine Rivers.

The natural flow of some of the wells has been observed on the higher portion of the water table and may be taken at about 30,000 gals. per well per day.

Detailed statements of the pumping tests of the wells at the corner of Mulligan Street and Nellie Ave., and Pacific Ave. and Nena Street are attached to this report.

The quantity obtained from the Mulligan Street well was 50 gals. per minute or 72,000 gals. per day.

The effect of pumping this well on the surface level of the water table was observed. When pumping the maximum quantity, the surface of the water at A, B and C was lowered from 2 to 3 feet and at D from 3 to $3\frac{1}{2}$ feet.

The natural flow of this well is 22 gals. per minute.

The quantity of water obtained from the well at the intersection of Pacific Ave. and Nena Street was in round figures 10 gals. per minute, the natural flow being from 2 to 3 gals. per minute. The level of the water in neighboring wells was not effected by pumping this well.

In this connection the following particulars of the well sunk by the Canadian Pacific Railway at their shops here, which have been kindly furnished by Mr. Whyte, are of value.

The diameter of the well is 16 feet, the depth 28 feet with 4 holes each 5 inches in diameter bored 35 feet further, total depth being 63 feet.

The .water at rest stands 6 feet below the surface, when pumping the water is 14 feet from the surface. The well yields 150.000 gals. per day or 37,500 gals. per each 5 in hole.

From the information obtained there appears to be no practical difficulty in the way of obtaining a sufficient supply for City use from this source.

A combined system of reservoir well and tube wells would probably be the best to adopt, in collecting the water for pumping.

The cost of a collecting system suitable for the City estimating the yield of each tube well at 30.000 gals. per day would be approximately $25,000. This is exclusive of pumping machinery, softening plant, buildings, mains, etc.

It is estimated that from this plant the yield would be 3,000,000 gals. per day without lowering the surface of the water at the wells more than 10 feet. Larger draughts could be made for short times in case of fire, etc.

In order to be safe from possible pollution and to take advantage of the greatest available head, the collecting system should be located in the western portion of the City, not less than about 2 miles from the rivers.

In order to guard against pollution of the wells by future settlement, the quantity of land reserved for the wells should be such that there would be no danger of the supply being contaminated by cess pits or refuse of any kind. Probably 160 acres should be the least quantity reserved.

COMPARISON OF WELL AND RIVER WATERS.

Neither of the sources of supply now under consideration being contaminated by sewage and it being clear that the Assiniboine may be used for many years before there will be any

danger of contamination the water which in other respects is of the more healthy character, and most useful for domestic and manufacturing purposes, should be chosen.

From Dr. Drown's report it will be seen that the well water is not considered objectionable from a sanitary standpoint.

In comparing the sources of supply, viz.—the Assiniboine River and Artesian Wells, the examinations and analyses show:

1ST.—QUALITY.

Neither of the waters is of the best, nor is either considered seriously objectionable from a sanitary standpoint.

2ND.—QUANTITY. (PERMANANCE OF SUPPLY.)

The Assiniboine River is much more than sufficient for all purposes.

The Artesian Well supply is no doubt permanent, and sufficient in quantity. Some of the wells now supply from 20,000 to 30,000 gallons per day from natural flow.

3RD.—FILTERING AND SOFTENING.

Both waters can be very much improved by a filtering and softening process. In the case of the Assiniboine water careful filtration is absolutely necessary during the spring and summer months.

When filtered and softened the waters will be practically equal in quality.

4TH.—LIABILITY TO CONTAMINATION.

As settlement increases on the Assiniboine, unless most stringent regulations to prevent it are carried out, there will no doubt be a certain liability to contamination of the water. It is not thought that the well waters are at all liable to contamination and if proper precautions are taken to reserve a sufficient

quantity of land about the wells to prevent close settlement there would never be any danger of contamination.

It is therefore possible to prevent either water being contaminated.

The Water Works situation in Winnipeg may be summed up as follows:

The City is now supplied by a Company under a charter, giving it a monopoly which will expire on 23rd Dec., 1900, or about four years from the present time.

The quantity of water supplied by the Company is less than one-half of the requirements of the City.

The pressure under which the water is delivered is insufficient for direct fire protection.

The mains, about 23 miles, are not of sufficient capacity for fire protection purposes, and are not of sufficient extent for domestic supply. Some of the mains, probably about five miles, are of doubtful strength for fire pressure.

The source of supply, the Assiniboine river, while uncontaminated by sewage at present, and while there is no cause for alarm on this account, may in the future become unfit for drinking purposes, and at present (during high water) it requires a careful and thorough filtration, which, from want of necessary plant, it does not receive. In order to remove the sediment from the Assiniboine water very extensive filtering plant and settling basin will be necessary.

There appear to be three courses open to the Council.

FIRST. To arrange with the present Company for an extension and increase in strength of their mains, the erection of hydrants and increased water pressure for fire protection, also for an efficient system of filtration, or a change in the source of supply.

SECOND. To construct a new system which will be ready for the supply of water by time the Company's monopoly expires. The particulars of such a system are given in Appendix 1.

THIRD. A combination of the above courses by incorporating with the new system such portions of the present system as may prove to be satisfactory and suitable for the purpose.

In considering what course to adopt the following facts should be borne in mind.

While a water works system could be constructed in one year it would for many reasons be desirable to distribute the work and expenditure over three seasons. This would leave only one season in which to do the preliminary work, decide upon details, prepare plans, etc.

While it would be very satisfactory for the City to own a completely new system, the present Company have a large amount of capital invested which should be utilized as far as possible without impairing the efficiency of the new system.

I would recommend for the consideration of the Council, therefore, the following mode of proceeding.

To acquire by arbitration or direct purchase the works of the present Company.

To extend the mains to about 40 miles, reinforcing and replacing the old mains where necessary.

To arrange the new distributing system so that wells can be used as a source of supply.

In the meantime to arrange for the proper filtration of the Assiniboine water.

I have the honor to be,

Your obedient servant,

H. N. RUTTAN,
City Engineer.

APPENDIX 1.

Cost of a New System of Water Works.

WINNIPEG, 6th May, 1895.

THE CHAIRMAN AND COMMITTEE,

GENTLEMEN:—

In accordance with your instructions I beg to submit the following report on a system of water works for the City of Winnipeg, intended to utilize the underground water supply.

The system is arranged to ultimately supply a population of 100,000 on the district covered by the mains.

The pipe system as shown on the accompanying plan covers about 85 miles.

It is estimated that about 40 miles of mains are required for the present population.

It is proposed to provide 2 pumping plants of 4,000,000 gals. capacity per day each.

This plant would furnish a domestic, manufacturing and sanitary supply for a population of 40,000 in addition to a fire protection supply of 10 hose streams of 275 gals. per minute each or a larger number of smaller streams.

The following is a general description of the proposed works:

The characteristics of the underground water supply have been fully discussed in former reports dated 26th September, 1892, and 26th October, 1894.

Fifty wells are to be bored at such distances apart as may be found from test wells to be desirable. The wells are to be

connected by suitable piping with a receiving reservoir of 4,000,000 gals. capacity. The supply pipes from the wells will also be connected with the pumps.

From the receiving reservoir the water for domestic consumption will be conveyed to the softening reservoir, and from the latter will be pumped into the mains.

The details of the softening plant cannot be determined without expert chemical advice. For the purpose of this report the cost has been placed at that of similar works elsewhere. It is proposed that the softening plant at present should have a capacity of 2,000,000 gals. per day.

By the use of meters on the domestic services it is expected that the water consumption will be reduced from the usually estimated 90 gals. per head, at times of maximum draught, to 60 gals per head.

In the proposed works a larger supply has been provided for fire protection than has been usual.

The domestic service has also been provided for a minimum population of 40,000 in mains and pumping plant. The most approved practice of using no mains less than six inches in diameter has been adopted.

Should the City acquire the mains of the Water Works Company most of them could be used in connection with the proposed system.

In the following estimate the cost of the distribution system has been given for populations of 100,000 and 40,000. The cost of pumping and softening plant, etc., has been given for a popuation of 40,000.

Your Obedient Servant,

H. N. RUTTAN,
City Engineer.

ESTIMATED COST.

For Population of 100,000. For Population of 40,000.

Pipe Size.	Length. Feet.	Cost per Foot.		Total 100,000	Total 40,000
18 ins.	4,750	$ 5 00	$23.750 00		
16 "	6,060	4 25	25,755 00		
14 "	12,530	3 50	43,855 00		
12 "	31,260	2 60	81,276 00		
10 "	50,640	2 00	101,280 00		
8 "	60,855	1 70	103,453 50		
6 "	281,720	1 30	366,236 00		
85 miles				$745,605 50	$360,000
Valves.	Number.	Cost Each.			
18 ins.	3	100 00	300 00		
16 "	4	75 00	300 00		
14 "	13	60 00	780 00		
12 "	20	50 00	1,000 00		
10 "	36	40 00	1,440 00		
8 "	56	30 00	1,680 00		
6 "	464	20 00	9,280 00		
				14,780 00	6,800
Hydrants.					
8 ins.	368	130 00	47,840 00		
6 "	235	100 00	23,500 00		
				71,340 00	27,000
Services	15,000	20 00		300,000 00	60,000
				1,131,725 50	$453,800

Brought Forward		$453,300
Pumping Engines, Boilers, etc.		40,000
Softening Plant		50,000
Wells and Connections		10,000
Reservoir		10,000
Buildings		15,000
Land		16,000
Allow for connection from end of system as shown on plan to pumphouse		8,000
Engineering, Interest, Contingencies		47,200
		$650,000

APPENDIX 2.

Mineral Constituents & Remarks re Winnipeg Waters.

[DR. HUTTON.]

WELL WATERS.

The acids and bases contained in the different well waters correspond and are as follows :

Acids	Carbonic.	Bases	Calcium.	Mg.	So.4	18.1	Grains per Gal.
	Sulphuric.		Sodium.	Ca.	Co.3	15.1	
	Nitric.		Magnesium.	Na.	Cl.	28.2	
	Hydrochloric.		Silicon.	Si.	O.2	1.96	
			Aluminium.	Al.2	O.3	1.83	
				So.3		16 34	
				Mg.	O.	6.02	

In all cases two half gallon bottles of water were taken from each source and complete analysis made from each bottle.

There was no charring or blackening on ignition of the residue from any of the well waters.

The high percentage of chlorine appearing in the well waters is undoubtedly due to mineral rather than organic contamination.

The percentage of free and saline Ammonia is not uncommon in deep wells, and is of little significance.

The low percentage of Albuminoid Ammonia would indicate that whatever organic impurities may have been present at the source of the well waters have been sufficiently oxydized and and filtered out to render it quite safe.

The serious objection of "Hardness" and excessive quantity of dissolved solids might in part be overcome by a suitable softening and filtering process.

The Diarrhœa frequently complained of by people when they first commence to use the water, is explained by the pre-

sence of Sulphate of Magnesia, (Epsom Salts). Beyond the temporary inconvenience it is harmless.

ASSINIBOINE RIVER WATERS.

Assiniboine Water Contains :

Bases	Calcium.	Carbonic.	Acids
	Sodium.	Sulphuric.	
	Magnesium.	Hydrochloric.	
	Silica.	Nitric.	
	Alumina.		
	Iron, (trace)		

On gently igniting the residue from the river water there was blackening, indicating Organic impurity.

The excessive amount of Albuminoid Ammonia, with comparatively small quantity of Chlorine and free Ammonia, is indicative of vegetable contamination and, according to English and European standards, absolutely condemns the water in its natural state for drinking purposes.

Softening and proper filtration would effect a great inprovement, and by a suitable process the water might be rendered fit for use.

(Signed),

W. A. B. HUTTON.

APPENDIX 3.

DR. DROWN'S REPORT.

At your request I have examined carefully the results you sent me of the chemical analyses of the waters from the Winnipeg artesian wells in connection with your description of the topographical and geological features of the region. I have also made chemical analysis of a sample of water of one of the artesian wells, and of a sample from the Assiniboiue River.

With regard to the free ammonia and chlorine reported in the analyses made in Winnipeg and Montreal, I will say that it is highly improbable that they have any connection with recent surface pollution. Free ammonia is very frequently found in deep artesian well waters; its origin is not always known, but in most cases it is clearly to be referred to nitrogenous matter geologically so remote, that it has no sanitary significance.

Should the free ammonia prove to be permanently characteristic of the well waters there seems to me little question from the geological structure of the region that its origin must be referred to the rocks and not to the surface contamination.

The sample of water from these wells which I received on October 10th, contained no free ammonia. I do not know how to explain this result, in view of the fact that all the samples you have had analyzed contained from 0.013 to 0.022 part of free ammonia per 100,000, unless it is assumed that the water underwent some change during the week of transportation from Winnipeg. Whether the water in the wells themselves is undergoing a change of composition can only be determined by further analysis. The high content of chlorine is clearly referable to salt deposits in the rocks. You mention in your letter of September 19th that there are strong salt springs near lake Manitoba and possibly there may be salt deposits nearer the

wells. If the free ammonia and chlorine had their origin in surface pollution of the nature of sewage there would be a larger amount of nitrates in the water. In the sample you sent me the nitrogen in the form of the nitrates was only 0.0700 part per 100,000, an amount which is quite insignificant in comparison with the chlorine. It will be noticed also that there is practically no nitrogen in the form of nitrites.

From your letter I infer that you think it possible there may be contamination of the well waters by decomposing vegetable matter existing in surface waters which communicate with the wells. I have not the advantage of a knowledge of the region from personal inspection but from the data submitted to me it appears that the gathering ground of the water which supplies these wells is so far distant that the possibility of any organic contamination reaching the wells is very remote. Moreover the analyses show that the amount of organic matter remaining in the water as indicated by the albuminoid ammonia and oxygen consumed is very small.

The large amount of mineral matter in the waters and their decided hardness are of course objectionable. The hardness could be in great part removed by some of the well known processes of softening the water and the aperient character of the water would be at the same time lessened. There are many water supplies in our western country in calcareous and magnesian regions with as high mineral contents as the Winnipeg wells and they are, I believe, only productive of temporary inconvenience to those unaccustomed to their use. I do not know that hard water of this character has any injurious effect on the system.

(Signed) T. M. DROWN.

Chemist Mass. State Board of Health.

APPENDIX 4.

ANALYSES OF WINNIPEG WATERS.

Date of Collection.	SOURCES.	PHYSICAL CHARACTERS.	Total Solids. Grains per gal. 100 c.	Nitrogen estimated as free Ammonia parts per 100 m.	Nitrogen estimated as Albumin'd Ammonia parts per 100 m.	Chlorine parts per 100 m.	Nitrogen as Nitrates parts per 100 m.	Nitrogen as Nitrites parts per 100 m.	Oxygen consumed and Metallic iron, parts per 100 m.	DEGREE OF HARDNESS. Total.	Temp.	Perm.
					WELLS.							
1892 Aug. 4	Exhibition Grounds.	1 Bright, clear water, nearly colourless	78.3	0.018	0.006	24.8				28	9	19
Aug. 4	Exhibition Grounds.	2 Bright, clear water, nearly colourless.....	75.6	0.016	0 006	25.4				30		
Aug. 16	Brookside..... ..	Cloudy, light brown colour, deposits slight brown sediment on standing...	77.9	0.016	0.004	25.4				29		
Aug. 16	Logan Ave west of C.P.R.	Cloudy, light brown colour, slight deposit on standing	76.60	0.013	0.003	24.3	Nitrates and Nitrites, 0142. (Zinc & Copper couple)			27	9	18
Aug. 24	Young Street	Bright, clear, nearly colourless, deposits slight sediment on standing.....	80.5	0.019	0.004	27.1				30		
Aug. 24	McDermot Ave....	Bright clear, nearly colourless	80.80	0.019	0.004	25.1				30		
Oct 10-15	Exhibition Grounds, "Drown Dr."...	1 Slight 'clayey turbidity, very slight sediment....	74.90		0.0034	23.42	0.0700	0.0001	Metallic Iron, 0500.	55 Equiv. to to Carb. lime 1 in 100 m. parts.		
Sept.	Brookside, Girdwood	....	78.00	0 ~~016~~ .006	0 016	27.40				23		
Sept.	Logan Ave. "	....	78.00	0.022	0.010	24.70				23.5		

Aug. 30	Assiniboine River, before filtering 'Hutton'	Slightly turbid, after clearing by subsidence has a slight brownish yellow color	53.1	0.0074	0.029	2.80	Nitrates and Nitrites, 0092, Zinc and Copper couple, Aluminium method, 0074.	Oxygen consumed in 15 min. .165 in 4 hours .477 both at 80 dgs fah.	24	6	18
	Assiniboine River after filtering, Hutton		44.4	0.0030	0.0242	2.28					
Oct 10-15	Assiniboine River, 'Drown.'	Distinct clayey turbidity—considerable earthy and woody sediment. Odour (cold) faintly vegetable. Odour (hot) distinctly vegetable and woody.	41.02			2.45		Metallic iron, 1200.	40		

Analyses from Reports of the Massachusetts State Board of Health, 1887-90.

	Sources.											
Surface Waters.	Lymm	Breed's Pond	2.69	0.0018	0.0214	Chlorine, Normal.	0.0042	0.0001	0.0409			
	Gloucester	Dike's brook storage resv'r.	3.27	0.0069	0.0229		0.0044	0.0002	0.0478			
	New Bedford	Conduit	3.63	0.0015	0.0248		0.0150	0.0001	0.0570			
	Lymm	Birch Pond	2.74	0.0019	0.0272		0.0065	0.0001	0.0528			
	Wayland	Storage Reservoir	3.11	0.0020	0.0298		0.0108	0.0001	0.0614			
	Leominster	Haynes Reservoir	2.22	0.0023	0.0409		0.0067	0.0001	0.0758			

APPENDIX 5.

WINNIPEG, 30th September, 1896.

To the Chairman and Members of the Provincial Board of Health.

GENTLEMEN —

Re Assiniboine River as a source of supply for drinking water.

This river is a branch of the Red River of the North, and joins the latter at Winnipeg.

Its drainage area is about 50,000 square miles, almost all prairie. Considering the great extent of this drainage area the flow of the river is extremely small.

The following table gives some statistics of this and other streams, shewing the relations between the drainage area, rainfall and the flow.

DATA OF FLOW OF STREAMS.

In cubic feet per second, per square mile of drainage area.

STREAM.	LOCALITY.	Drainage Area.	Annual Rainfall.	Maximum flow in cubic ft. per sec.	Minimum flow in cubic ft. per sec.	Ordinary flow in cubic ft. per sec.
		Sq. Mls.	Ins.			
Sudbury	Framingham, Mass.....	.78	44	41.385	.036	.353
Croton.....	Croton Dam, N.Y.....	339	48	74.867	.178	1.109
Merrimack ..	Lawrence, Mass.	4,599	43	20.874	.300	.600
Connecticut..	Hartford, Conn.....	10,154	44	20.235	.513	.....
Deleware....	Lambertville, N.J.....	6,820	44	51.320	.290	. ....
Potomac	Great Falls, Md.	11,476	42	15.249	.093	.....
Kanawha ...	Charleston, Va., Pool...	8,900	44	13.291	.123	. ....
Missouri	St. Charles, Mo..... ..	527,600	19	0.816	.028	.. ...
Minnesota .	Ft. Snelling, Minn	16,027	28	3.7436	.050	.156
Mississippi ..	Minneapolis, Minn.	19,585	27	3.0636	.100	.250
Red River .	National Boundary	39,577	21	.....	.030	.074
Assiniboine.	Winnipeg, Manitoba....	58.352	18	1.0283	.016	.044

High water occurs in May, and extremely low water in November, from which time until spring the water remains at about the same level.

From the above table it will be seen that the minimum flow of the Assiniboine is only about 600 cubic feet per second, or .016 cubic feet per square mile of drainage area and about half that of the Red River. This is due in part to the comparatively small rainfall, but chiefly to the very great evaporation which takes place over the vast extent of exposed prairie watershed.

Levels.

For its first 15 miles from its junction with the Red to Headingly, the river consists of a number of almost level stretches separated by small rapids, the total fall in this distance being 26 ft. At Baie St. Paul, 35 miles from Winnipeg, the elevation is about 70 feet, and at Portage la Prairie, 60 miles from Winnipeg, about 80 feet higher than at Winnipeg.

The above distances are those by road. The sinuosities of the river make the distance by water above Headingly nearly three times as great. Between Headingly and its junction with the Red, the River is comparatively straight.

The Effect of the Population on the Contamination by Sewage of the River.

It has been found by the Massachusetts State Board of Health after careful and extended investigation, that during extreme low water in the eastern rivers, a population on the watershed of seven persons per square mile caused an increase of chlorine of .01 parts in 100,000. On account of the flow of the Assiniboine being much less than that of the eastern rivers, a smaller number of persons on the watershed would cause the same amount of sewage contamination.

On the settled portions of the river, on account of the higher land of the banks affording dryer building sites, the woods affording shelter, and the convenience to water in the river for stock in winter, all the dwellings, barns and stock yards are placed upon the immediate banks, and it is the almost universal practice of the residents to use the river as a dumping place for all kinds of refuse and offal. Manure is got rid of by throwing it into the river. Surface washings from barnyards, stockyards and hogpens during every rainfall find their way into it directly

by natural ravines or artificial ditches, whilst the soakage from all is continuously going on. In fact the river is used as the common sewer of the country.

The number of persons per square mile in the Assiniboine water shed probably does not exceed ½ person per square mile at the present time, a number so small that under ordinary circumstances they would have no appreciable influence in the sewage contamination of the stream, but of more importance on account of the long narrow shape of the river lots; the location of their dwellings, outbuildings and yards; the large proportion of stock kept by each; and the common mode of disposing of manure instead of using it as a fertilizer. While, therefore, there is no ground for present alarm from this cause, the indications are that in the not distant future, as settlement increases, most stringent measures will have to be enforced to prevent a continually increasing pollution of this stream, or a new source of drinking water supply will have to be selected by the City of Winnipeg.

Filtration.

Between Portage la Prairie and Winnipeg the river banks are sedimentary and at all stages of water, except the lowest, are subject to constant and very great erosion, so that for six months in the year the water carries in suspension great quantities of finely divided clay and sand. It is possible at considerable expense to remove this. The best system for this purpose would probably be settling basins of sufficient capacity and subsequent filtration. Without settling basins, efficient filtration is impracticable, the large quantity of the sediment rapidly clogging the apparatus.

It is considered that this large quantity of sediment carried by the water is at the present time its most objectionable feature.

We have the honor to be, Sirs,

Your obedient servants,

JAMES PATTERSON,
Chairman Board of Health.

H. N. RUTTAN,
City Engineer.